(54) Title: COIN DISCRIMINATING DEVICE AND METHOD
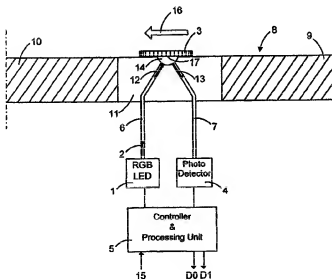
(57) Abstract

A coin discriminating device has light emitting means (1) for projecting light (2) onto a surface of a coin (3), optical sensor means (4) for detecting light reflected from the coin, and processig means (5) for determining a type of the coin by comparing coin data obtained from the optical sensor means with reference data related to different types of coins. The light emitting means (1) is arranged to emit monochromatic light in a visible, infrared or ultraviolet wavelength range. The optical sensor means (4) and the processing means (5) are arranged to produce spectral charateristics data for light reflected from the coin surface and to compare the spectral characteristics data with spectral coin reference data for determining the type of the coin (3).

COIN DISCRIMINATING DEVICE AND METHOD

Technical Field

The present invention relates to coin discriminators, particularly of the kind comprising light emitting means for projecting light onto a surface of a coin, optical sensor means for detecting light reflected from the coin, and processing means for determining a type of the coin by comparing coin data obtained from the optical sensor means with reference data related to different types of coins. The present invention also relates to a coin discriminating method.

Description of the Prior Art

Coin disciminators are used in e.g. coin sorting/counting machines for identifying the type (e.g. denomination) of each coin that is processed by the machine. Furthermore, coin discriminators are used in coin inspection systems for sorting out foreign coins, fake coins and coins that are unfit for further circulation (due to e.g. excessive wear). Some coin discriminators operate inductively by exposing the coins to an alternating magnetic field by means of one or more than one coil and detecting an electrical characteristic in response to the magnetic field exposure, for instance the decay of eddy currents induced in the coin.

Inductive coin discriminators are often able to successfully identify the metallic composition of the coin, thereby allowing a determination of the coin denomination by additionally using measurement data related to e.g. the coin diameter. However, not all coin types are distinctive enough, in terms of their magnetic and electric characteristics, to allow differentiation by means of an inductive coin discriminator. For instance, prior art discriminators

have failed to differentiate 20 NOK Norwegian coins from 50
GRD Greek coins.

A different and considerably more expensive kind of
coin discriminators is optical pattern recognition discri-
minators, which produce e.g. a grey-scale photograph of the
coin surface and identify the coin type by image analysis
methods and comparisons with stored coin reference data.
Optical pattern recognition discriminators of this type are
shown in EP-A-0 798 669 and EP-A-0 798 670 and comprise
light emitting means for projecting light onto a surface of
a coin, optical sensor means for detecting light reflected
from the coin, and processing means for determining a type
of the coin by comparing data obtained from the optical
sensor means with reference data related to different types
of coins. However, some specific types of coins have
similar magnetic and electric characteristics as well as
similar surface patterns (coin stamps). To successfully
identify also such coins, a combination of inductive and
optical pattern recognition discriminators would appear
necessary, the obvious drawback being a major cost penalty.

Summary of the Invention

The object of the present invention is to solve the
problem set out above and provide accurate identification
of coins of different types and denominations, even if
their magnetic, electric and surface pattern characteris-
tics are very similar.

The object is achieved for a coin discriminating
device as set out above by arranging the light emitting
means, the optical sensor means and the processing means to
produce spectral characteristics data for light reflected
from the coin surface and by comparing the spectral charac-
teristics data thus obtained with spectral coin reference
data for determining the type of the coin.

An important aspect of the present invention is the
realization that "tricky" coin types as described above may
be differentiated by providing a device and a method for
determining and evaluating the color of the coin surfaces.
5 Other objects, features and advantages of the present in-
vention appear from the following detailed disclosure, from
the drawings as well as from the appended claims.

Brief Description of the Drawing

10 The present invention will now be described in more
detail, reference being made to the accompanying drawings,
in which:

FIG 1 is a schematic top view illustrating a prefer-
red embodiment of a coin discriminating device according to
15 the invention,

FIG 2 is a flow chart depicting a preferred embodi-
ment of a method according to the invention, and

FIG 3 is a bar chart diagram of the spectral distri-
bution obtained from the method of FIG 2 for an exemplary
20 coin.

Detailed Disclosure of the Invention

As shown in FIG 1, the coin discriminator according
to the preferred embodiment comprises an RGB light emitting
25 diode (LED) 1, which is arranged adjacent to a first end of
a first optical fiber 6, the second end 12 of which is con-
nected to a recess 14 in a coin path 8. Furthermore, the
coin discriminator comprises a photodetector 4 and a second
optical fiber 7, which extends from a first end at the
30 photodetector 4 to a second end 13 at the recess 14. A com-
bined controller and processing unit 5 is operatively con-
nected to the RGB diode 1 and the photodetector 4. The
processing unit 5 has a control input 15 and data outputs
D0 and D1.

The coin path 8 provides a plane surface, along which
a coin 3 may move from a first position 9 to a second posi-
tion 10 in a direction indicated by an arrow 16 in FIG 1.
The coin 3 may be arranged to roll along the path 8, pref-
5   erably by arranging the path 8 at a declination from the
first position 9 towards the second position 10. Alterna-
tively, the coin 3 may be carried along the path 8 by ac-
tive driving means, such as a belt or a resilient carrier
member. A typical application for the inventive coin dis-
10 criminator will be in a coin counting and/or sorting
machine, wherein the path 8 is part of a coin processing
stage inside the machine. Coin counting and/or sorting
machines as such are common general knowledge and are not
described in more detail herein.

15   According to the preferred embodiment, an additional
coin sensor 11 is arranged along the path 8. The additional
coin sensor operates inductively for determining type-
related coin parameters, such as metal alloy composition.
However, the additional coin sensor 11 is well-known per se
20 and does not form an essential component of the present in-
vention. Consequently, the present invention may be applied
without the use of such an additional coin sensor 11.

The first and second optical fibers 6 and 7, which in
the preferred embodiment have a cross-sectional diameter of
25 about 2 mm, are arranged to illuminate a small spot 17 on
the surface of the coin 3 with light 2 emitted by the RGB
diode 1 and to receive and forward light reflected from
said spot 17 to the photodetector 4. More specifically, the
RGB diode 1 comprises three light emitting diode elements
30 integrated as one component and arranged to emit red, green
and blue light, respectively. The combined controller and
processing unit 5 is arranged to control which of the three
colors that will be emitted from the RGB diode 1 at a re-
spective moment. Depending on the color of the surface of
35 the coin 3, the intensity of the light reflected in the

spot 17 will be different for red, green and blue light, respectively.

With reference to FIG 2, a complete measurement is executed as follows. In the beginning, the procedure is initiated by the controller and processing unit 5 in a step 100, wherein internal variables, temporary parameters, etc., are reset. Being controlled by the controller and processing unit 5, the RGB diode 1 then first emits a pulse of red light (in a step 110), the reflection of which is detected in a step 120 by the photodetector 4 and registered by the processing unit 5. Subsequently, the RGB diode 1 emits a pulse of green and blue light in steps 130 and 150, respectively, and the respective reflections are detected and registered by the photodetector 4 and processing unit 5 in respective steps 140 and 160.

Once all three colors have been emitted and detected, the detected reflection intensity values are adjusted in a step 170 according to calibrated values, so as to remove any influences from a defective, dirty or dull coin surface. Preferably, the calibration values are determined for a perfectly white surface and only once, e.g. during the manufacturing of the coin discriminator.

After having corrected the detected reflection intensity values according to the above calibration, the relative distribution of the three colors (red, green and blue) are calculated in a step 180 by the processing unit 5. By accessing an electronic memory operatively connected to the processing unit 5, the unit 5 analyzes and compares, in a step 190, the relative reflection intensity values with a plurality of prestored coin reference data, so as to determine in a step 200 a type of the coin 3 in the form of a surface color. Preferably, the processing unit 5 is arranged to differentiate between at least the colors of copper, silver and gold. The relative distribution of these colors are indicated for an exemplary coin in FIG 3.

When the type or color of the coin 3 has been deter-
mined by the processing unit 5, the result of the determi-
nation is available at the outputs D0 and D1. According to
the preferred embodiment, the outputs D0 and D1 are given
values according to the following table:

D1	D0	Meaning
0	0	No coin
0	1	Copper
1	0	Silver
1	1	Gold

The control input 15 is used by other components in
e.g. the coin counting and/or sorting device for activating
the coin discriminator.

Thanks to the inventive coin discriminator, it is
possible to differentiate among coins which are very simi-
lar as regards their magnetic and electric characteristics
as well as their surface pattern or coin stamp, such as the
20 NOK and 50 GRD coins referred to above, provided that
such coins exhibit a difference in surface color. When it
comes to the two exemplary coin types above, the 20 NOK
coin has a silver color, while the 50 GRD has a gold color.

For enhanced accuracy the measurements may be re-
peated a number of times for each color. An average reflec-
tion intensity value will then be calculated and used by
the processing unit 5 for determining the coin type. The
preferred embodiment described above operates by emitting
narrow-band monochromatic light in three discrete wave-
length ranges and by broadly detecting the intensity of the
reflected light at the respective wavelength ranges. Accor-
ding to an alternative embodiment, the emitting diode 1 is
instead arranged to emit white or broadband light, wherein
the photodetector 4 is arranged to operate in narrow bands
around a few discrete wavelengths, such as red, green and

blue light. Furthermore, the coin discriminator may operate
with less than three colors or with more than three colors,
as will be readily realized by a man skilled in the art.
However, for accurate coin discrimination, the best
5   solution is believed at the moment to involve the use of at
least three different colors.

The light emitted by the diode 1 may range from
ultraviolet light to infrared light, i.e. the present in-
vention is not limited to the use of wavelengths within the
10   visible range.

The invention has been described above with reference
to a few embodiments, the purpose of which is to exemplify
the invention but in no way to limit the same. Therefore,
the invention may be carried out in other ways than the
15   ones described above, and the scope of the invention is
only limited by the appended independent patent claims.

CLAIMS

1. A coin discriminating device, comprising: light
emitting means (1) for projecting light (2) onto a surface
of a coin (3); optical sensor means (4) for detecting light
reflected from the coin; and processing means (5) for de-
termining a type of the coin by comparing coin data ob-
tained from the optical sensor means with reference data
related to different types of coins, **characterized** in that
the light emitting means (1) is arranged to emit
monochromatic light in a visible, infrared or ultraviolet
wavelength range, and in that
the optical sensor means (4) and the processing means
(5) are arranged to produce spectral characteristics data
for light reflected from the coin surface and to compare
the spectral characteristics data with spectral coin
reference data for determining the type of the coin (3),

2. A coin discriminating device as in claim 1, fur-
ther comprising means for forming a path (8), along which
said coin (3) travels from a first position (9) to a second
position (10).

3. A coin discriminating device as in claim 2,
wherein said path (8) comprises a coin detector (11) dif-
ferent from the optical sensor means (4).

4. A coin discriminating device as in claim 2 or 3,
further comprising a first light guiding means (6) arranged
between the light emitting means (1) and said path (8).

5. A coin discriminating device as in claim 4, fur-
ther comprising a second light guiding means (7) arranged
between the optical sensor means (4) and said path (8).

6. A coin discriminating device as in claim 4 or 5,
wherein a respective end (12, 13) of the first and second
light guiding means (6, 7) is arranged adjacent to a recess
(14) in said path (8).

5

7. A coin discriminating device as in any of claims
4-6, wherein the first and/or second light guiding means
(6, 7) comprise(s) an optical fiber.

10   8. A coin discriminating device according to any pre-
ceding claim, wherein the light emitting means (1) com-
prises at least one light emitting diode (LED).

9. A coin discriminating device according to any
15 preceding claim, wherein the processing means (5) is ar-
ranged to provide an output signal indicative of one of a
copper surface, a silver surface or a gold surface of the
coin (3).

20   10. A coin discriminating method, wherein: a surface
of a coin (3) is irradiated with light (2); light reflected
from the coin surface is detected; reflection data related
to at least a portion of the coin surface is produced from
the reflected light; and a type of the coin is determined
25 by comparing the reflection data with reference data
related to a plurality of coin types, **characterized** in that
    the coin (3) is irradiated with monochromatic light
(2), and in that the reflection data and the reference data
relate to the spectral characteristics of coin surfaces
30 when exposed to monochromatic light.

11. A method as in claim 10, comprising the steps of:
illuminating a spot (17) on the coin surface with monochro-
matic light of a first color and detecting a first reflec-
35 tion thereof; illuminating said spot with monochromatic

light of a second color and detecting a second reflection
thereof; illuminating said spot with monochromatic light of
a third color and detecting a third reflection thereof; de-
termining a relative distribution of the first, second and
5   third reflections; and determining the type of the coin (3)
from said relative distribution.

12. A method as in claim 11, wherein the first, sec-
ond and third colors comprise red, green and blue.

10

13. A method as in any of claims 10-12, wherein said
coin type relate to the color of the coin surface.

14. A method as in any of claims 10-13, wherein said
15   coin type is determined as one of a copper color, a silver
color or a gold color.

FIG 1

FIG 2
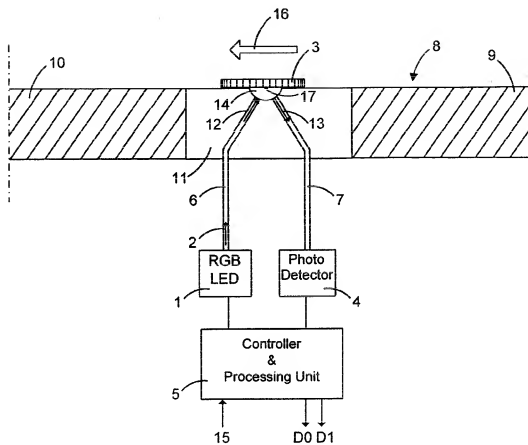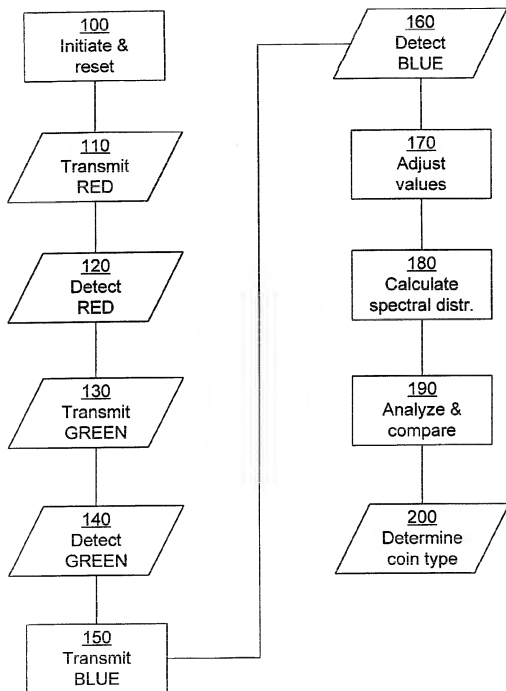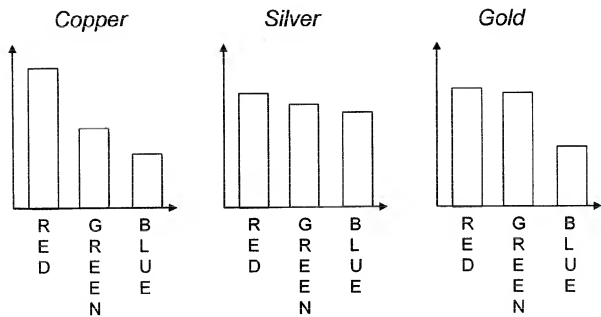


```
100
Initiate &
reset

110
Transmit
RED

120
Detect
RED

130
Transmit
GREEN

140
Detect
GREEN

150
Transmit
BLUE

160
Detect
BLUE

170
Adjust
values

180
Calculate
spectral distr.

190
Analyze &
compare

200
Determine
coin type
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FIG 3

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G07D 5/00 // B07C 5/342
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G07D, B07C, G07F, G01J

Documentation searched other than minimum documentation to the extent that such documentation are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	Patent Abstracts of Japan, abstract of JP 9-218968 A (GLORY LTD), 19 August 1997 (19.08.97) --	1-3,9,10,13, 14
X	WO 9623281 A1 (CHIPPER 2000 (ISLE OF MAN) LIMITED), 1 August 1996 (01.08.96), abstract --	1,2,8,10
X	WO 9634258 A1 (CHIPPER 2000 (ISLE OF MAN) LIMITED), 31 October 1996 (31.10.96) --	1,10,13

X	Further documents are listed in the continuation of Box C.		X	See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2000	2 7 -04- 2000
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Gunilla Jonsson / MR Telephone No. + 46 8 782 25 00

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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